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# LONG-DISTANCE RELATIONSHIP WITH THE MEDITERRANEAN WORLD? GOLD BEECH-NUT PENDANTS FOUND IN THE EARLY IRON AGE CHINA AND THE EURASIAN STEPPE

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## ABSTRACT

The gold technology in Northwest China underwent an important development during the early Iron Age, following the arrival of new technological skills from the central Asian steppes. These developments included the use of granulation, filigree, and sheet metal, working with mould or matrix. This paper presents a micro-analytical study of an array of gold pendants excavated from the burial site at Dongtalede (9th-7th century BCE) in the Altai region of Xinjiang. It opens up new perspectives for exploring how cultural interactions were perceived, conveyed, disseminated and preserved through material culture in a society where there was little textual evidence. We conducted multiple non-destructive analyses to examine chemical composition and manufacturing techniques using a hand-held optical microscope (OM) and scanning electron microscopy with an energy dispersive spectrometer (SEM–EDS). Our findings represent the earliest evidence of diffusion bonding technology in ancient China. We find that the stylistic features of the beech-nut pendants are closely linked to the Mediterranean world, but archaeometric analyses attested to local production. Comparing the pendants with the growing body of goldwork discovered at sites in Northwest China, Central Asia, the Southern Urals and the Eastern Mediterranean, demonstrates that there were extensive contacts across ancient Eurasia that occurred much earlier than the opening of the commercial Silk Roads.

**KEYWORDS**: Gold beech-nut pendants; early China; Xinjiang Altai; diffusion bonding; Eurasian Steppe; Mediterranean world; Black Sea; Southern Urals

## 1. INTRODUCTION

From a very early period, gold functioned in ceremonial, ritual and mortuary contexts in ancient Eurasia. Recent stylistic analyses of early goldwork found in Northwest China have shown that gold items present a complex mix of indigenous and foreign traits and influences (So & Bunker 1995; Yu & Ma 2013: 53-59; Yang & Linduff 2013: 53-59; Rawson 2015a: 53-59; Liu et al. 2021a: 1-29). Gold was a foreign material that was used to highlight important local values. Therefore, it provides a unique window into the relationship between China and the rest of the world. The current interdisciplinary study examines gold artefacts with a distinctive beech-nut design found in Northwest China and the Eurasian steppe, which date from the 9th to the 4th century BCE.

The Dongtalede cemetery in the Southern Altai Mountains was excavated by the Xinjiang Institute of Cultural Relics and Archaeology and the Cultural Relics Academy of Haba River County in 2011. The cemetery is located in Haba River County, part of the Aletai area, Xinjiang Uygur Autonomous Region (Fig. 1). It contains 61 burial sites. At least five individual tombs (M3, M5, M6, M7, and M32) yielded more than 800 gold objects, including gold pendants, granulated ornaments, thin appliqués embossed with boars and leopards, and openwork gold ornaments shaped as ibexes, wolves, and antlered animals (Xinjiang 2013: 4-18). The burial mound of tomb 3 (M3) comprises an oval-shaped stone slab measuring 15.3 m in diameter and 0.4 m in height. The burial chamber was opened in the middle part of the oval stone-slab. It contained a stone chamber and a wooden coffin that had partially perished. Although the burial site was looted in ancient times, a range of gold ornaments survived from the robbery. An adult female and a teenage girl were buried in this tomb, accompanied by 140 gold appliqués embossed with tigers and snow leopards. Archaeologists of the Peking University had analyzed the remains of the skeletons and stated that they dated from the late 9th century to the middle of the 7th century BCE.


***Figure 1. Map showing geographical distribution of Dongtalede cemetery and other archaeological sites,9th-4th century BCE, adapted from Simpson and Pankova eds. 2017: 159***

Of particular interest in the collection is an array of gold pendants. Each pendant is shaped like a beech nut with four lobes (Fig.2). There is a perforation at the terminal of each pendant, indicating that the object was originally attached to other parts of the ornaments. Similar designs were also found in the decoration of gold jewelry from the elite burial sites dating from the early Iron Age Eurasia, such as the Eleke sazy Kurgan (8th-7th century BCE) in eastern Kazakhstan (Samashev et al. 2018: 109-117), Burial mound 1 (4th century BCE) of Filippovka I in the southern Urals (Yablonsky 2015: 97-108), and Kurgan 8 in the necropolis of Mecet-Saji (5th-4th century BCE) of the Black Sea region (Parzinger 2007: 170), and far west to the Mediterranean world. Their wide distribution and stylistic similarities allow us to re-think the early contacts between ancient China and the Mediterranean world. They suggest that these connections occurred much earlier than the opening of the commercial Silk Roads during the imperial expansion of the Han court from the 2nd century BCE.


*Figure 2. Gold beech-nut pendants found in tomb 3 of Dongtalede, the Xinjiang Altai region, Northwest China*

The current research provides the first scientific study of the gold beech-nut pendants found in tomb 3 of Dongtalede cemetery. Using multiple non-destructive analytical methods, such as hand-held optical microscope (OM), and scanning electron microscopy with energy dispersive spectrometer (SEM–EDS), we investigated the manufacturing techniques and elemental composition of the array of gold pendants from the Dongtalede site that currently preserved in the Xinjiang Autonomous Region.

The results of this study reveal that the early development of the precious metalworking industry in Northwest China has been experiencing at the beginning of mobile pastoralism in the 9th-6th centuries BCE could well have been prompted by the arrival of some new technologies and craftworking practices from Central Asia, as well as extensive contacts with the Eurasian steppes and far west to the Mediterranean world. The artistic impact from the Far West, and the critical role played by Greek goldsmiths in transcultural interactions and the production of prestige goods in Eurasian Antiquity, have been extensively discussed by many scholars (Sören 2012: 106-139; Boardman 2015: 102-128; Cunliffe 2015: 227-228). Yet there were few research works concerning new archaeological findings in China, and the great potential of material culture studies to better understand transnational flows of peoples, objects, technologies and ideas has not been fully explored. The current paper attempts to characterize these issues, and it brings the archaeometric study into the domains of art historical inquiry and archaeological interpretation, drawing comparisons between manufacturing techniques, styles and iconography. It is argued that the gold beech-nut pendants found in Dongtalede cemetery were the local inventions that occurred as a response to outside stimuli in the Early Iron Age Eurasia.

## 2. SAMPLES AND METHODS

### 2.1. *Samples for analyses*

The array of gold pendants consisted of ten small beech-nut-shaped objects with four lobes (Fig.3). Each object was constructed in two parts in the form of elliptic leaves made from a thin gold sheet, measuring 13.12-14.00 mm in length and 5.12-6.33 mm in width. They were joined together (Table 1). The objects were perforated at the ends, suggesting that they were originally attached to other ornaments or clothing. They are currently threaded with a cotton wire together for preservation.

***Table 1 Dimensions of the selected samples for analysis***

| sample | numbers for analysis | object | length | width (mm) | Weight (g) |
|---|---|---|---|---|---|
| M3:1-3 01 | 1 | Gold pendant 01 | 13.81 | 6.02 | 3.40 |
| M3:1-3 02 | 1 | Gold pendant 02 | 13.76 | 6.03 | |
| M3:1-3 03 | 1 | Gold pendant 03 | 13.85 | 5.77 | |
| M3:1-3 04 | 1 | Gold pendant 04 | 13.58 | 6.33 | |
| M3:1-3 05 | 1 | Gold pendant 05 | 13.78 | 5.55 | |
| M3:1-3 06 | 1 | Gold pendant 06 | 13.52 | 6.17 | |
| M3:1-3 07 | 1 | Gold pendant 07 | 13.12 | 5.12 | |
| M3:1-3 08 | 1 | Gold pendant 08 | 13.25 | 5.12 | |
| M3:1-3 09 | 1 | Gold pendant 09 | 14.00 | 5.52 | |
| M3:1-3 10 | 1 | Gold pendant 10 | 13.66 | 6.10 | |

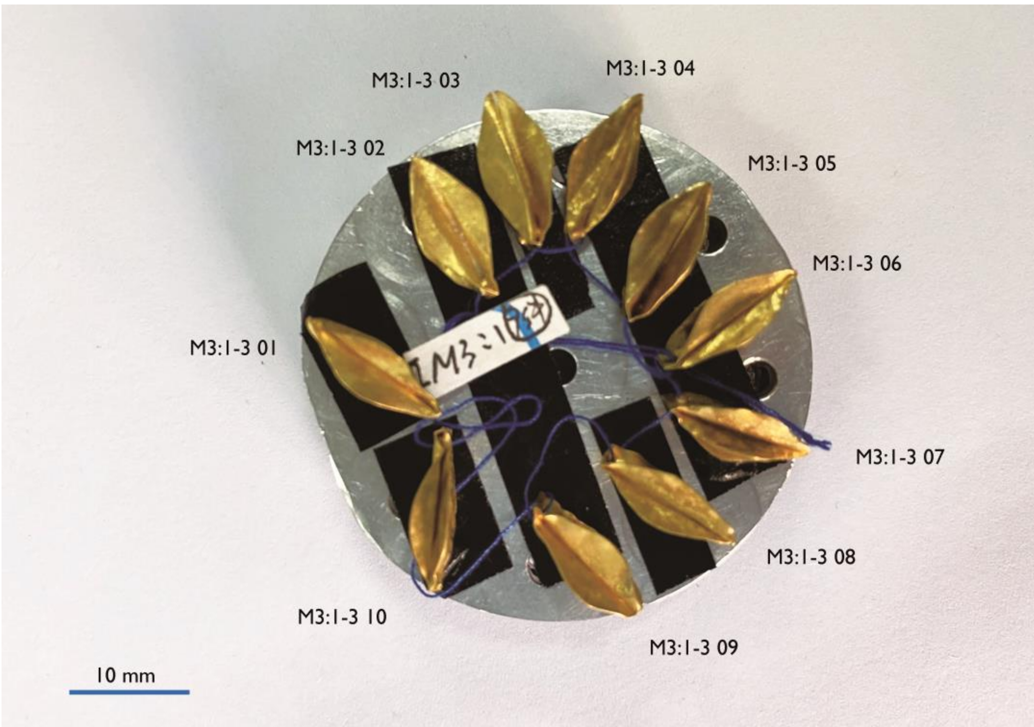


*Figure 3. Samples for analysis*

## 2.2 *Analytical methods*

*Optical microscopic analysis (OM).* In the initial survey, a hand-held microscope (Dino-lite edge digital microscope) was used to examine tool marks and surface details of the objects at the Xinjiang Uygur Autonomous Region Museum.

*Scanning electron microscopy with energy dispersive spectrometer (SEM–EDS)*. The morphology analyses were performed using a SEM (ZEISS SUPRA 55VP, Germany). This gave detailed information on the purpose of refining information on some details of the manufacturing process, such as the tool marks of hammering and polishing. The composition analyses used an EDS (BRUKER X-FLASH-SDD-5010, Germany). The SEM–EDS operating conditions were in line-avg mode with 20 kV accelerating voltage and an EDS working distance of around 8–9 mm. The measurement time for each analysis was set to 40 seconds, with around 10% of dead time to maintain Si-Li detector saturation. Standardless calibration mode was employed with ESPRIT 1.9 software, with the default critical energy line series selected for each targeted element (e.g., copper K lines). The beam size was 40 µA. The minimum detection limit for gold, silver, and copper is 0.10%. The standard deviation is around 1%, and the relative error is around ±3%. At least three micro-areas were analyzed in every zone, and the elemental results detected were averaged and normalized.

# 3. RESULTS

Gold is the most malleable of all known metals. It is often hammered into thin sheets that can be easily rolled and folded were often made by hammering. In the current study, the SEM-EDS analyses provided information on the morphology of the pendants' shaping and the elemental composition of the different areas. Different technologies were involved, such as sheet working, plastic deformation, and welding. In addition, optical analyses of tool marks and surface typography aimed to provide a better understanding of the manufacturing techniques.

## 3.1 *Manufacturing techniques*

The examinations by OM and SEM illustrate that the manufacture of the beech-shaped pendants involved highly skilled craftsmanship, as indicated by the smart design of the sheet work. The thin sheets varied in thickness from 120.6-208.2 um. They were formed by hammering. The metal sheets maintained their ductility during the hammering process, which was interspersed with annealing (Fig. 4 a). The perforation at the terminal of the pendant was pierced. Each nut was made from one piece of shaped sheet gold folded over (Fig. 4 b). The surface and lobes of the pedant were carefully burnished (Fig. 4 c). Some irregular flakes of metal were folded around the edges of the objects, as shown in the SEM image of sample M3:1-3 05 (Fig. 4 d), suggesting the edges were additionally polished.

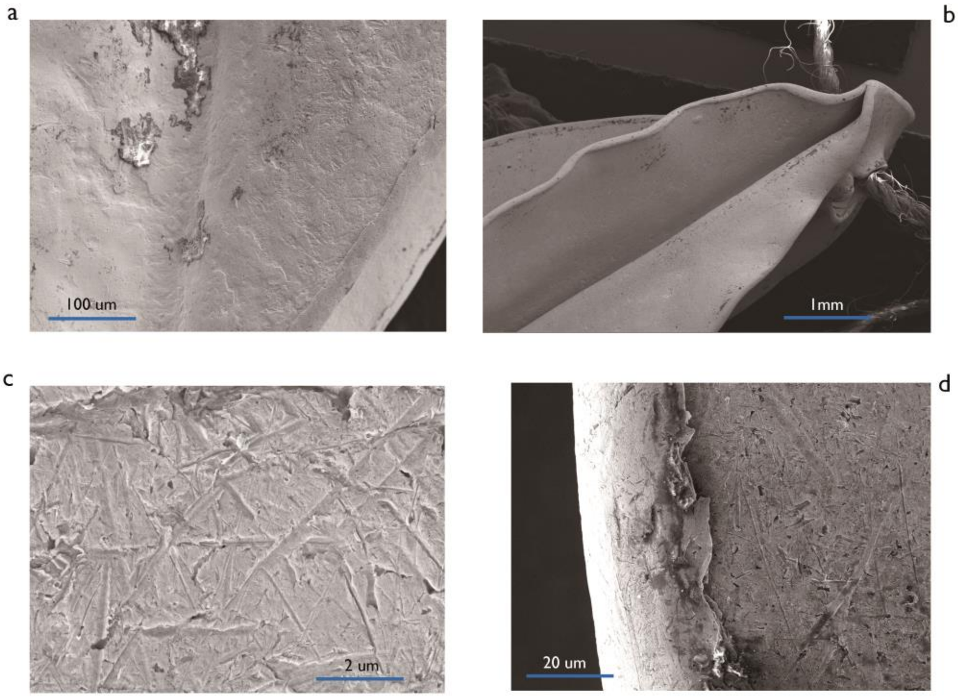


***Figure 4. SEM images of sample M3:1-3 05 (a) the details of the hammering; (b) the edges of the gold pendant; (c) the underside of the folded edge; (d) the burnishing marks on the surface of the gold leaves***

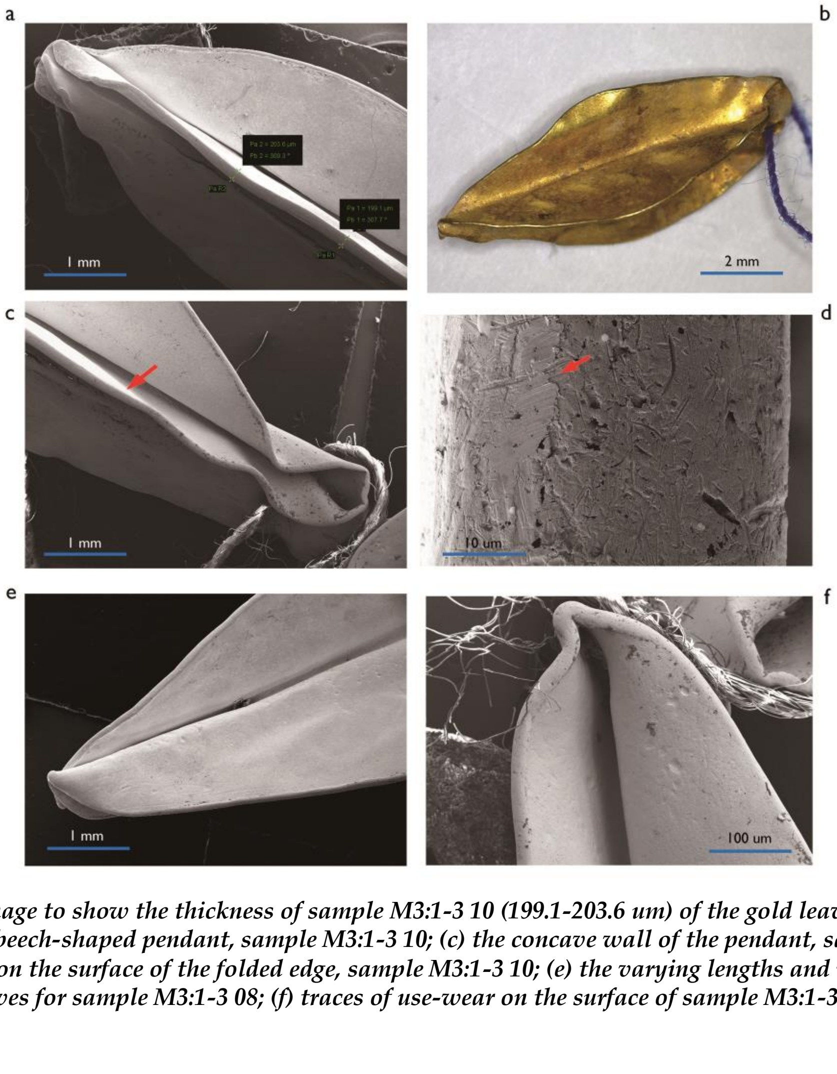


***Figure 5. (a) SEM image to show the thickness of sample M3:1-3 10 (199.1-203.6 um) of the gold leaves; (b) OM image of the structure of the beech-shaped pendant, sample M3:1-3 10; (c) the concave wall of the pendant, sample M3:1-3 10; (d) the polishing marks on the surface of the folded edge, sample M3:1-3 10; (e) the varying lengths and widths of the elliptic leaves for sample M3:1-3 08; (f) traces of use-wear on the surface of sample M3:1-3 01.***

Each pendant was shaped in the form of a beech nut with slight differences in size and ornamental details. The objects were structured with two folded elliptic leaves with four lobes. The thickness of each lobe was not the same, measuring between 199.1 and 203.6 um for sample M3:1-3 10 (Fig. 5 a) and between 123.9 and 140.3 um for sample M3:1-3 07. The two leaves were cut of the same thin gold sheet, then folded in half and joined together. A dislocation of the two parts could be observed under the microscope (Fig. 5 b). Fig. 3c shows the bending mark of the thin gold sheet, and the surfaces and the edges of the leaves appear very smooth (Fig. 5 c). The underside of the lobe for sample M3:1-3 10 illustrates that tiny metal flakes folding around the edge were heavily polished and flattened out (Fig. 5 d). Also, the varying lengths and widths of the elliptic leaves suggest that they were made by freehand (Fig. 5 e). Traces of use-wear, such as tiny bumps and scratches are also visible on the surface of the pendant (Fig. 5 f).

The SEM-EDS results of elemental composition showed that most of the joining points of this set of gold pendants were the same, but the surface structure of the joints showed a different pattern. Under SEM, the jointing area could be clearly seen between the two folded gold leaves (Fig. 6 a), and the result showed a granular structure (Fig. 6 b) of the joints for samples M3:1-3 05 and M3:1-3 08 (Fig.6 c), indicating that alloy powders were used for fusing, and such a bonding took place in a solid state (Echt & Thiele 1993:435-451). Meanwhile, the dendric crystallization as evidence of melting could be clearly seen in the welding area of M3:1-3 05 (Fig. 6 d). More strikingly, in the joining area, measuring about 350.5 um in width (Fig. 6 e), the rippling effect as evidence of partial melting is visible on the surface of sample M3:1-3 02 (Fig.6 f). The EDS analyses of the joining areas and the substrates indicated that there were no compositional changes in the welding zone (Table 3).

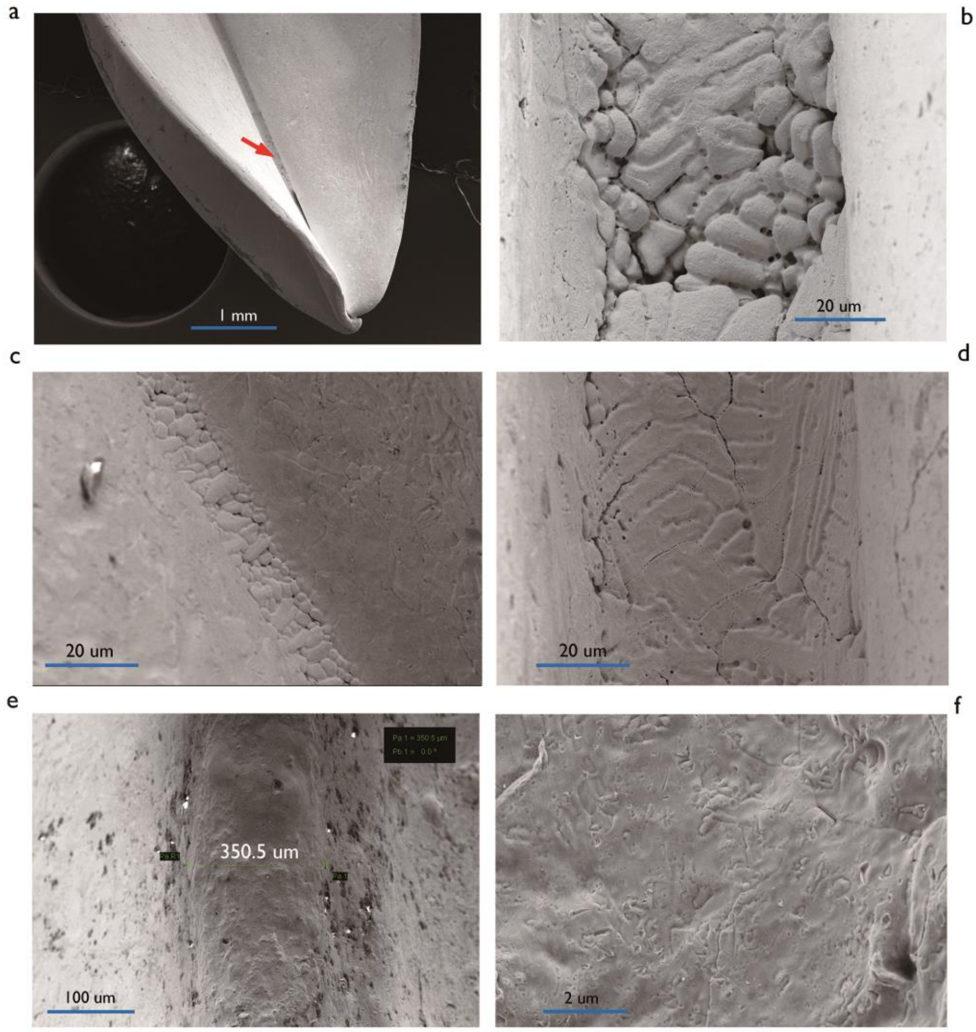


*Figure 6. (a) The joint between two folded leaves, sample M3:1-3 05; (b) SEM images showing the microstructure of the welding, sample M3:1-3 05; (c) the granular structure of the joint as evidence of sintering, M3:1-3 08; (d) the dendritic crystallization as evidence of melting on the surface of the joint, M3:1-3 05; (e) the welding area of sample M3:1-3 02; (f) the rippling effects on the surface of the joint, M3:1-3 02*

### 3.2 Elemental Composition

The analytical data obtained in the frame of this study are presented in Table 2, where the concentrations of gold (Au), silver (Ag), copper (Cu) and Iron (Fe) in the investigated gold pendants are presented. Remarkably, the concentration of Au is between 90.40 and 98.54 wt.%. The Ag content is consistently below 10 wt.%, and the Cu and Fe contents are both below 1 wt.%. In other words, the pendants are composed of almost pure gold.

Therefore, we can conclude that all the finds were prepared from native gold without any intentional addition of silver or copper. The gold pendants contained a similar alloy composition (Table 2). This purity has also been found in other gold artefacts from the same period in the Lixian site in Gansu province, and Liangdaicun cemetery in Shaanxi province (Yang et al. 2017). Micro-analyses showed that the pendant contained similar gold alloys (Table 3). The EDS analysis demonstrated that the content of gold (91.37-98.28 wt.%) and silver (1.13-7.76 wt.%), copper (0.10-1.72 wt.%), and iron (0.03-1.86) contents for the joints were very similar to the surrounding areas, which contained 90.4-98.54 wt.% gold, 1.41-9.03 wt.% silver, 0.01-0.74 wt.% copper, and 0.03-0.96 wt.% iron. These results, combined with the microscopic examination of the objects, indicate that the diffusion bonding was employed to fuse the pendant components with the gold powders that were similar in composition to the joining parts. The analogous elemental composition of the set of gold pendants and the very similar typologies of the artefacts suggest that these small objects were made in a single workshop.

***Table 2 EDS Results of Elemental Composition of Dongtalede gold (wt.%, normalized to 100%)***

| Sample | Object | Area | Spot | Metal Elements | | | |
|---|---|---|---|---|---|---|---|
| | | | | Au | Ag | Cu | Fe |
| M3:1-3 01 | pendant 01 | substrate | 01a | 94.77 | 4.75 | 0.28 | 0.20 |
| | | substrate | 01b | 95.39 | 3.98 | 0.41 | 0.22 |
| | | substrate | 01c | 94.55 | 4.80 | 0.63 | 0.02 |
| | | **average** | | **94.90** | **4.51** | **0.44** | **0.15** |
| M3:1-3 02 | pendant 02 | substrate | 02a | 98.54 | 1.45 | 0.01 | - |
| | | substrate | 02b | 97.11 | 1.51 | 0.42 | 0.96 |
| | | substrate | 02c | 97.83 | 1.32 | 0.32 | 0.53 |
| | | **average** | | **97.69** | **1.35** | **0.23** | **0.73** |
| M3:1-3 03 | pendant 03 | substrate | 03a | 93.31 | 5.58 | 0.96 | 0.15 |
| | | substrate | 03b | 92.95 | 6.19 | 0.43 | 0.43 |
| | | substrate | 03c | 96.18 | 3.11 | 0.47 | 0.24 |
| | | **average** | | **94.15** | **4.96** | **0.62** | **0.27** |
| M3:1-3 04 | pendant 04 | substrate | 04a | 96.18 | 3.23 | 0.37 | 0.22 |
| | | substrate | 04b | 96.16 | 3.24 | 0.08 | 0.52 |
| | | substrate | 04c | 96.03 | 3.31 | 0.25 | 0.41 |
| | | **average** | | **96.12** | **3.27** | **0.23** | **0.38** |
| M3:1-3 05 | pendant 05 | substrate | 05a | 93.11 | 6.40 | 0.16 | 0.33 |
| | | substrate | 05b | 91.63 | 7.72 | 0.30 | 0.35 |
| | | substrate | 05c | 93.31 | 6.57 | 0.07 | 0.05 |
| | | **average** | | **92.68** | **6.90** | **0.18** | **0.24** |
| M3:1-3 06 | pendant 06 | substrate | 06a | 96.22 | 3.35 | 0.05 | 0.38 |
| | | substrate | 06b | 97.28 | 2.23 | 0.27 | 0.22 |
| | | substrate | 06c | 96.96 | 2.59 | 0.35 | 0.10 |
| | | **average** | | **96.82** | **2.73** | **0.22** | **0.23** |
| M3:1-3 07 | pendant 07 | substrate | 07a | 91.77 | 7.72 | 0.48 | 0.03 |
| | | substrate | 07b | 90.40 | 9.03 | 0.37 | 0.20 |
| | | substrate | 07c | 91.57 | 7.84 | 0.39 | 0.20 |
| | | **average** | | **91.25** | **8.20** | **0.41** | **0.14** |
| M3:1-3 08 | Pendant 08 | substrate | 08a | 94.83 | 4.06 | 0.50 | 0.61 |
| | | substrate | 08b | 97.54 | 1.59 | 0.37 | 0.50 |
| | | substrate | 08c | 95.22 | 4.24 | 0.51 | 0.03 |
| | | **average** | | **95.86** | **3.30** | **0.46** | **0.38** |
| M3:1-3 09 | pendant 09 | substrate | 09a | 97.26 | 1.64 | 0.46 | 0.64 |
| | | substrate | 09b | 97.78 | 1.45 | 0.35 | 0.42 |
| | | substrate | 09c | 97.69 | 1.47 | 0.51 | 0.33 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | **average** | | **97.58** | **1.52** | **0.44** | **0.46** |
| M3:1-3 10 | pendant 10 | substrate | 10a | 95.18 | 3.33 | 0.85 | 0.64 |
| | | substrate | 10b | 96.17 | 2.90 | 0.64 | 0.29 |
| | | substrate | 10c | 93.06 | 5.09 | 0.52 | 1.33 |
| | | **average** | | **94.80** | **3.78** | **0.67** | **0.75** |

*Table 3 EDS results of the joining areas and the substrates (wt.%, normalized to 100%)*

| Sample | Object | Area | Spot | Composition | | | |
|---|---|---|---|---|---|---|---|
| | | | | Au | Ag | Cu | Fe |
| M3:1-3 02 | pendant 02 | **joint** | **J01** | **97.54** | **1.81** | **0.62** | **0.03** |
| | | substrate | 01a | 97.96 | 1.62 | 0.32 | 0.10 |
| | | substrate | 01b | 98.54 | 1.45 | 0.01 | - |
| | | **joint** | **J02** | **98.28** | **1.13** | **0.26** | **0.33** |
| | | substrate | 02a | 97.11 | 1.51 | 0.42 | 0.96 |
| | | substrate | 02b | 97.89 | 1.41 | 0.42 | 0.28 |
| M3:1-3 05 | pendant 05 | **joint** | **J03** | **93.32** | **6.39** | **0.22** | **0.07** |
| | | substrate | 03a | 93.11 | 6.40 | 0.16 | 0.33 |
| | | substrate | 04b | 91.63 | 7.72 | 0.30 | 0.35 |
| | | **joint** | **J04** | **92.93** | **6.94** | **0.10** | **0.03** |
| | | substrate | 04a | 93.31 | 6.57 | 0.07 | 0.05 |
| | | substrate | 04b | 91.47 | 8.12 | 0.22 | 0.19 |
| M3:1-3 07 | pendant 07 | **joint** | **J05** | **91.37** | **7.76** | **0.87** | **-** |
| | | substrate | 05a | 91.77 | 7.72 | 0.48 | 0.03 |
| | | substrate | 05b | 90.40 | 9.03 | 0.37 | 0.20 |
| | | **joint** | **J06** | **91.74** | **7.32** | **0.62** | **0.32** |
| | | substrate | 06a | 91.57 | 7.84 | 0.39 | 0.20 |
| | | substrate | 06b | 91.61 | 7.49 | 0.74 | 0.16 |
| M3:1-3 08 | pendant 08 | **joint** | **J07** | **92.79** | **6.54** | **0.46** | **0.21** |
| | | substrate | 07a | 94.83 | 4.06 | 0.50 | 0.61 |
| | | substrate | 07b | 97.54 | 1.59 | 0.37 | 0.50 |
| | | **joint** | **J08** | **93.66** | **5.37** | **0.58** | **0.39** |
| | | substrate | 08a | 96.99 | 2.51 | - | 0.50 |
| | | substrate | 08b | 95.22 | 4.24 | 0.51 | 0.03 |
| M3:1-3 09 | pendant 09 | **joint** | **J09** | **97.28** | **1.24** | **0.84** | **0.64** |
| | | substrate | 09a | 97.26 | 1.64 | 0.46 | 0.64 |
| | | substrate | 09b | 97.78 | 1.45 | 0.35 | 0.42 |
| | | **joint** | **J10** | **95.00** | **1.42** | **1.72** | **1.86** |
| | | substrate | 10a | 97.69 | 1.47 | 0.51 | 0.33 |
| | | substrate | 10b | 97.42 | 1.60 | 0.54 | 0.44 |

## 4. DISCUSSION

### *4.1 Technical features and manufacturing process of the Dongtalede pendants*

A technological analysis shows that hammering, cutting, and welding were used to produce the gold pendants from Dongtalede M3. Traces of use-wear can be seen on the surface of the objects. This indicates that the artefacts were used for an extended period and not just made for the burial. As mentioned, the ten gold pendants have an exceptionally high gold content of 95 wt.% or more. There were also small amounts of silver, copper, and iron.

It is possible to reconstruct the manufacturing process (Fig.7) of the gold pendants. It took place in three stages: (1) a gold ingot was hammered into a thin sheet, then was cut to shape before it was folded. When cutting the leaves, the craftsmen might have sketched an outline of the elliptic shape, indicated by the shallow incised lines on the surface (Fig. 8 a). The pendant was then pierced through from one side (Fig.8 b). (2) Each elliptic leaf was pinched and then folded up at a right angle to face in the opposite direction. As the gold was malleable, this was probably be done by hand, perhaps with the aid of a tool (maybe a blunt knife or metal stick) to create an axially symmetric plastic deformation. This is indicated by the presence of creases (Figs.8 c and 8 d). (3) The two folded elliptic leaves were joined together to create a four-lobed beech nut. The craftsmen have used alloy powders to join the two components when welding them. The welding was not seamless between the convex walls: some small gaps are visible. The pendants were almost certainly made freehand as evidenced by their varying dimensions. In earlier times, it was not easy to join the two convex walls together, leading to some technological flaws, such as the dislocation of the components (Fig.5 e).

There was no composition difference between the joints and the substrates, and the coexistence of the granular structure and the dendric crystallization on the surface of the joints attest to a hybrid of sintering and hot bonding, identified from the SEM images of the Dongtalede pendants. Both the autogenous welding and the sintering don't produce any compositional changes in the welding region (Echt & Thiele 1995: 435-451). Sintering is a solid phase bonding technique due to the use of gold powder of similar composition to the jointing parts. When pressed metal power is heated, the powder grains will join together by diffusion, usually to 65-80% of its solidus temperature, and they will form a porous solid body (Echt & Thiele 1995: 435-451). On the other hand, the autogenous welding occurs in a liquid state by direct heating without addition of any filter metal (Scrivano et al. 2016: 123-130). The evidence of solidification structure of molten metal (Fig. 6d) and the partial melting (Fig. 6 f), demonstrates that in the case of samples M3:1-3 02 and M3:1-3 05, the joining took place in a liquid phase.

*Figure 7. Reconstruction of working process to show how to make the beech-nut pendants. Drawing courtesy of Jack Ogden*

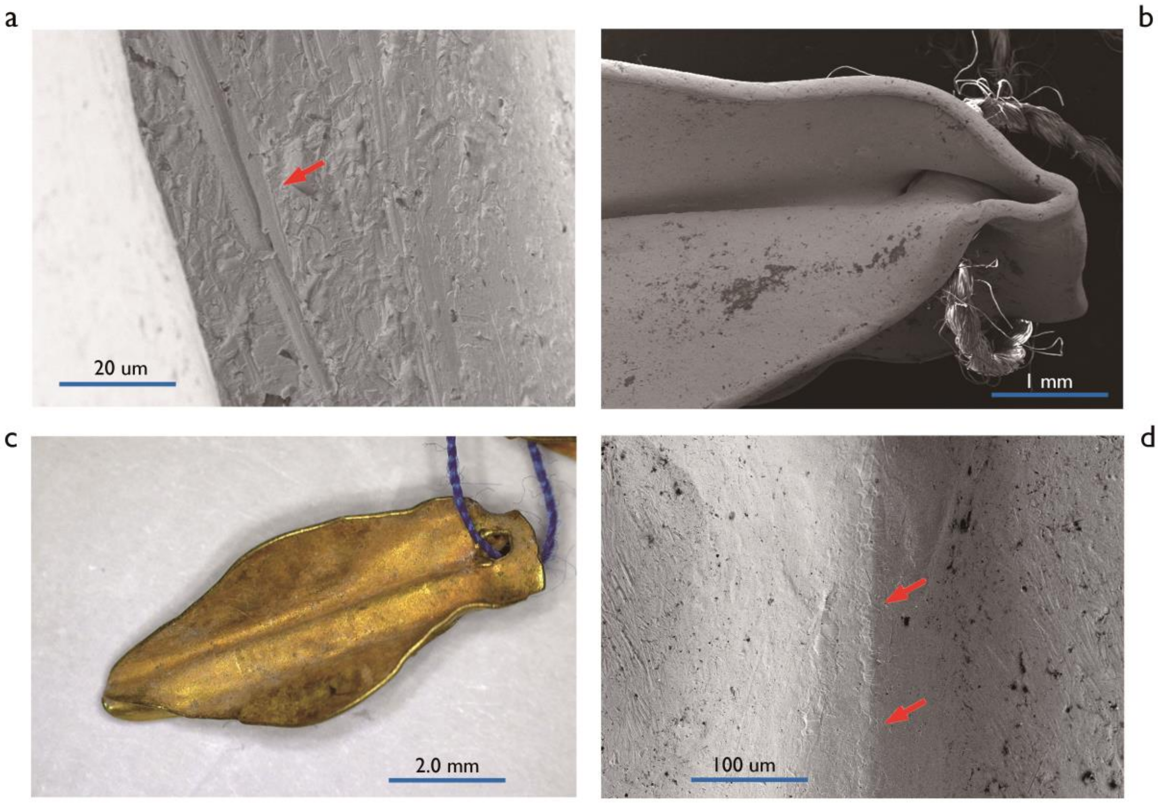


***Figure 8.** (a) SEM image showing the shallow carving mark on the surface of sample M3:1-3 10; (b) perforation of sample M3:1-3 09; (c) the longitude impression on the surface of gold leaves under the microscope; (d) SEM image showing the detail of the longitude impression on the surface of sample M3:1-3 01.*

## 4.2 Beech-nut pendants outside China

The use of gold occurred as early as 1600-1400 BCE in the Huoshaogou site of Gansu province, Northwest China, where two gold and ornamental rings were found to be hammered (An & An 2008: 291-310). In Bronze Age China, gold was often hammered into thin foils for decorating bone and lacquer objects. Many of these decorative foils were found at the

Yinxu site in Anyang, Henan Province (Yinxu 1987), as well as at other archaeological sites in northern China. Extraordinary finds include the gold masks with peculiar designs unearthed from the Sanxingdui site at Guanghan, Sichuan province (Sichuan 1987: 1-15). Meanwhile, gold artefacts, such as belt ornaments made by casting appeared in the 8th-6th century BCE burial sites at Tianma Qucun in Shanxi (Tianma-Qucun 1994: 4-28; Tianma-Qucun 2001: 4-55), and Shangcunling in Henan (Henan 1999), as well as Liangdaicun in Shaanxi (Shaanxi 2007: 3-22) in north China. Gold ornaments decorated with filigrees and granulations were mainly found in the burial sites on the Chinese northwest frontiers between 9th and 3rd century BCE, including the Dongtalede site in the Xinjiang Altai, the Dongheigou and Xigou cemeteries in the eastern Tianshan Mountains (Dongheigou 2009: 3-27; Xigou 2016: 15-31), and the Majiayuan cemetery (4th-3rd century BCE) in Gansu (Majiayuan 2014), and the Xigoupan and Aluchaideng sites in the Ordos region in Inner Mongolia (Guo & Tian 1980: 1-10; Tian & Guo 1980: 333-338). Some gold appliqués were made by local craftsmen in northern Chinese states for their nomadic neighbors (So & Bunker 1995: 53-67; Liu et al. 2021a: 1-29). The gold pendants from Dongtalede were unusual for their beech-nut design and the sophisticated manufacturing techniques employed.

Recent scholarship has suggested that the emergence of new manufacturing techniques and iconographies in precious metals between the 5th and 3rd centuries BCE indicate the influences of the nomadic neighbors on the precious metalworking in Northwest China, as well as connections with Central Asia preceding the early Iron Age (Yang & Linduff 2013: 73-84; Rawson 2015 b: 28-35). In recent years, the increasing discoveries in Northwest China, the Central Asian steppes and Southern Urals, especially the discovery of a group of gold beech-nut pendants with technological and ornamental similarities, have shown that there were close cultural contacts between the people of the Chinese northwestern frontiers and the mobile pastoralists of the Eurasian steppes. This contact began as early as the 9th-8th century BCE and even shows traces of connections that extend as far west as the Black Sea Region and the Mediterranean world.

### 4.2.1 The Central Asian Steppe and Southern Urals

In Eastern Kazakhstan, an array of beech-nut pendants with the same design as those found at Dongtalede finding was uncovered from a joint burial at Eleke sazy cemetery in the Tarbagatai mountains: mount 4 (8th -7th century BCE), which belonging to a young couple. This burial consisted of an oval-shaped stone-slab measuring 50 m in diameter. It was well preserved. To the left of the man's skullcap lay some gold jewelry, possibly from a headdress, as well as a deer head carved out of gold leaf in an inverted position. Two more deer-shaped appliqués were found between his left shoulder and the head. On the neck of the skeleton, there was a small feline plaque. A group of gold beech-nut pendants (Fig.9 a) were found to be buried with the female occupant of the grave, along with gold earrings, cylindrical beads, fragments of a piece of spiral gold wirework, a range of tubular beads, and multi-colored semi-precious stones (Samashev et al. 2018: 109-117; Samashev et al.2019: 126-139). A female headdress in the form of an ibex's head that had been decorated with a beech-nut pendant (Fig. 9 b) was found in kurgan 6 of Taksai I site (6th-5th century BCE) in western Kazakhstan, along with a pair of long pendants decorated with beech nuts and other plant seeds symbolizing fertility and abundance (Lukpanpva 2018: 132-155).

Another type of gold bead with a biconic shape was found in Eleke sazy. It resembled the designs as seen in the decorations in the gold ornaments found in Arzhan II (7th century BCE) in Tuva (Fig.10 a) in the Sayan-Altai region, as well as those found in Taldy II (Fig.10 b). The same style also appeared at an earlier time in the gold jewelry (Fig. 10 c) found in the royal tomb II (9th-8th century BCE) at Nimrud in present-day Mosul city, Iraq. This jewelry belonged to an Assyrian queen. In tomb II at Nimrud, the biconical beads were part of a necklace. They were found along with a gold crown, a diadem, and other lavish gold jewelry. The beads were suspended by chains soldered to the middle part of the beads, and the small cylindrical spacers separated the biconoids (Hussein 2016: 18). The homogeneity of the decorative style and typological features is evident in some of the gold artefacts found in Eleke sazy, Taldy II and Arzhan II, indicating a connection between early Sakas and the mobile pastoralists in southern Siberia. However, there was relatively little microscopic examination or elemental analysis of the biconical beads. As such, they could not be precisely localized.

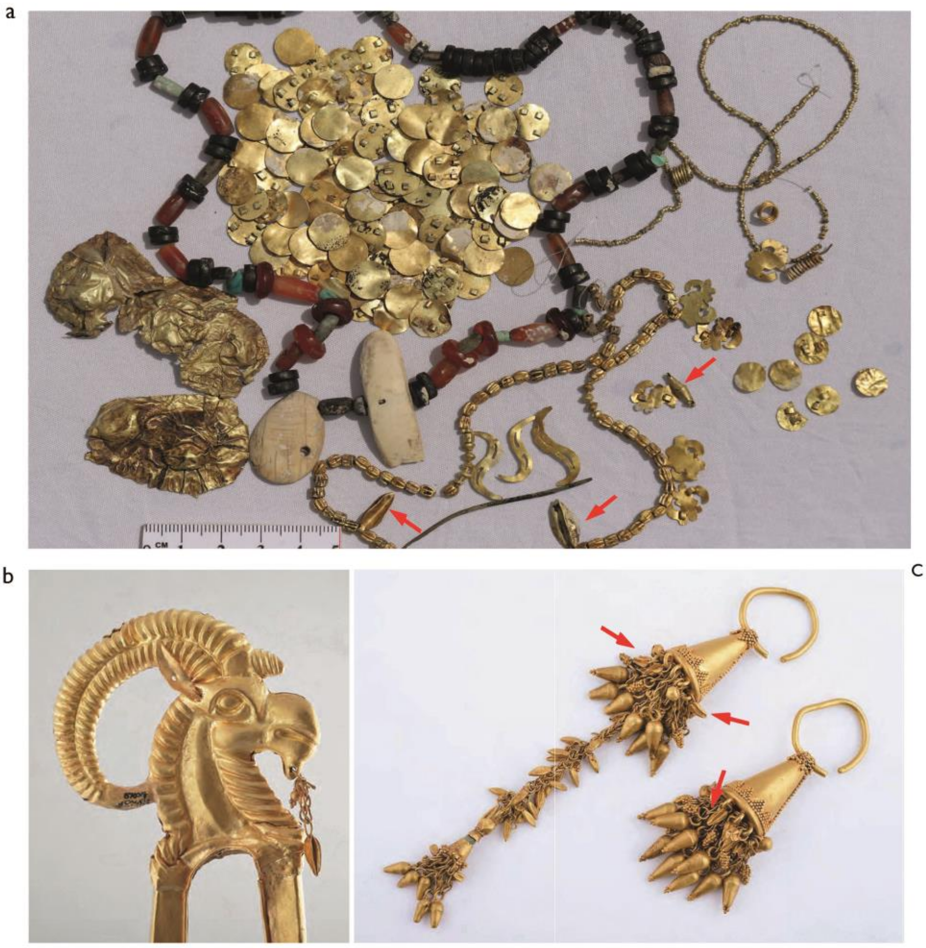

*Figure 9. (a) gold ornaments found in mound 4, Eleke-Sazy, East Kazakhstan, 8th-7th century BCE. After Samashev 2018: 128, fig.7; (b) gold headdress and (c) a pair of long pendants decorated with beech-nuts and other plant seeds from kurgan 6 of Taksai I, after Lukpanpva 2018, pp.148, fig.20 and pp. 139, fig.9*


*Figure 10. (a) gold biconic beads from Arzhan II (7th century BCE), Tuva. after Chugunov 2010; (b) gold biconic beads from kurgan 5 of Taldy II, Kazakhstan, after Beisenov 2014: 150; (c) gold biconic beads from tomb II of the Queen's tomb at Nimrud. after Hussein 2016: pl.47*

In the southern Urals, at least two comparative examples showed decorative styles that were similar to the Dongtalede pendants, though they dated from a later period. In an undisturbed burial site (mound 1) from Kurgan I in Filippovka in the Ural-Ilek interfluve (4th century BCE), a set of gold ornaments was found along with a wooden box, cages, glass, silver, gold earrings, and a large silver mirror. This burial belonged to a female adult. The deceased was dressed in lavish garments adorned with 395 gold appliqués in the form of rosettes, flowers and panthers (Yablonsky 2014: 16-20). The pendant from Kurgan 1 of Filippovka I appeared flattened (Fig.11 a), and it was soldered with granules onto the edge and small loops with gold chains. At the ends of the small chains, there were elongated, quadri-lobate pendants. The front surface of the pendants in the grooves between the lobes was decorated with a row of granulation across its length (Yablonsky 2015: 97-108; Yablonsky & Treister 2019: 79-161). Another gold pendant in the form of a boar figure (Figs.11 b and 11 c) was also found in Kurgan 1 of Filippovka I (Yablonsky 2013: 220). Like the Dongtalede object, it comprised several four-lobed beech-nut pendants. Each pendant was additionally ornamented with tiny granules in the form of a pyramid.


*Figure 11. (a) gold pendant from kurgan 1 of Filippovka I. after Yablonsky 2015: 101, fig.12; (b) gold pendant and (c) the detail of beech-nut pendant from kurgan 1, Filippovka. after Yablonsky 2013: 220, fig.3113.*

### 4.2.2 The Mediterranean World and the Black Sea Region

In Greece, the royal graves at the ancient citadel of Mycenae, dating from 1600-1500 BCE, yield a great variety of gold figurines, masks, cups, diadems, and jewelry, beads and buttons. The gold mines of Macedonia and Thrace, especially those of Mt Pangaion, were working from the 6th century BCE (Jackson 2013: 2949-2951). Gold jewelry was very rare between the 6th and 5th centuries BCE, but it flourished in the Greek colonies in southern Italy and Crimea. Beech-nut pendants have been found in three kinds of gold jewelry from these regions: strap necklaces, earrings, and diadems. Strap necklaces with beech-nut pendants have been found in many areas of the Greek world, including southern Italy, Asia Minor, and the North Pontic region. Earrings have been found in the Black Sea area. One diadem was discovered from the Scythian burial site near the Black Sea.

Strap necklaces with beech-nut pendants have been found in northern Greece, Asia Minor, Italy, and South Russia. Some of these have three rows of beech-nut pendants. Necklaces of this type became very popular in the Mediterranean world from the 5th to the 4th century BCE (Williams 1996: 117-129). Examples of this type of jewelry include the strap necklace unearthed in the tomb Z at Derveni (Fig.12 a) in northeast Thessaloniki, as well as the items found in Pella, Amphipolis and Corinth from a treasure trove. The straps were made up of four double loop-in-loop chains and a fringe of beech-nut pendants. These ornaments were produced with the same technical knowledge and had the same place of origin. They have been dated to 4th century BCE (Dági 2013: 85-103).

Frequent representations of the necklace with beech-nut pendants in Greek vase paintings, for instance, a volute krater by the Karneia painter at Taranto (Ilektra 1999: 40), Museo Nazionale Archaeologico (Fig.12b) attest to the popularity of this type. In addition, the 4th century BCE calyx-krater bears an elaborate gilded clay-relief decoration (Figs.12c and 12 d). It contains an image of the strap necklace with beech-nut pendants that hang down like a swag, with wreaths and earrings (Cohen 2006).

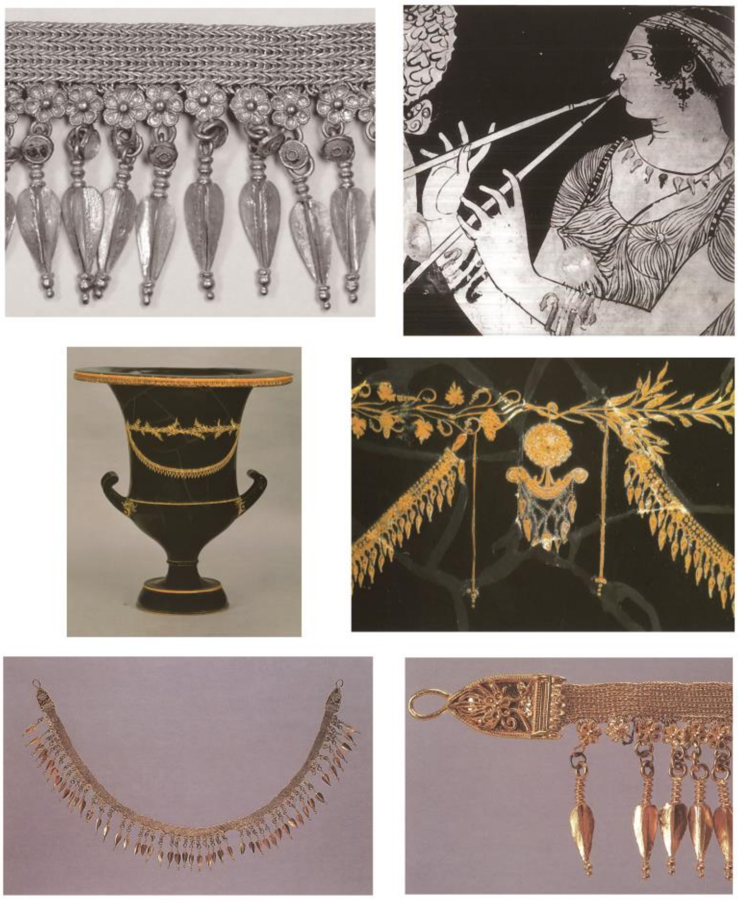

*Figure 12. (a) Strap necklace from Derveni, 4th century BCE, after Dági 2013: 93, fig.11; (b) a volute krater wearing a necklace with beech-nut pendants. 5th century BCE, after Ilektra 1999: 40; (c) Calyx-krater decorated with a gold necklace with beech-nut pendants, after Cohen 2008: 143; (d) detail of the beech-nut pendant;(e) Strip necklace from Kyme, 4th century BCE; (f) the detail of the pendants, after Williams & Ogden 1994: 99;*

*Figure 13. (a) Strap necklace with beech-nut pedants from the Great Bliznitza, 4th century BCE, after Williams & Ogden 1994: 191, fig.123; (b) strip necklace with beech-nut pendants from the Pavloysky kurgan, after Williams & Ogden 1994: 168; (c) gold earrings from Pyatimary I, 5th-4th century BCE, after Parzinger 2007: 190; (d) gold earring with beech-nut pendants from ancient Pydna, after Kypraiou 2000: 24, fig.10; (e) gold earrings with seed-like pendants from the Great Bliznitza, after Williams & Ogden 1944: 190*

Further evidence of similar necklaces was found in the Black Sea region. The strap necklaces with three-lobed beech-nut pendants are of different sizes in terms of the heights of the straps and the sizes of pendants. The pendants terminate in a cluster of tiny granules. Excellent examples include the gold strap necklace from Kyme (dated to the 4th or 3rd century BCE), which has the same design (Fig.12 e, f) as the Taranto vase painting, and the example with three rows of beech nuts found in the Great Bliznitza (Fig.13 a). Comparable examples were also found in a kurgan in Bolshaya Bliznitsa on the Taman Peninsula, and the Pavlovsky kurgan (Fig.13 b; Erciyas 2005: 95; Williams & Ogden 1994: 168).

In the Black Sea region, earrings with beech-nut pendants were archaeologically documented in the gold ornaments recovered from kurgan 8 (5th-4th century BCE) of the necropolis of Pyatimary I (Fig.13 c) at Mecet-Saji (Parzinger 2007: 170). Example were also found at the cemetery of ancient Pydna (Kypraiou 2000: 24). The earrings from Mecet-Saji were the nearest parallel to the Dongtalede find. They consisted of three strings of four-lobed beech nuts. The pendant was perforated so that it could be attached to a string of small chains. The earrings at the Pydna cemetery, consisted of an elaborate rosette with an inverted pyramidal device hanging from it (Fig.13 d). This was flanked by two strings of three-lobed beech-nut pendants terminating in small grains.

At this time, the seed-like pendant became to prevail in contemporary Greek goldwork with more elaborate designs. Intricate granulations and filigrees are shown in the boat earrings from the Great Bliznitza (Williams & Ogden 1994: 190). Attached to the lower edge of the boats were rosettes, behind which were a cluster of chains and ribbed, seed-like pendants (Fig.13 e). The pendants had two rows of grains at their corners and crosshatched panels on alternate ribs. The bodies of the seed-like pendants were made with two halves soldered together. They were therefore different from the beech-nut pendants, which were made of sheet metal. The seed-like pendants were often used for necklace ornamentation, and many examples have been found in Asia Minor and Melos. They were thought to be made in the same workshop (Williams & Ogden 1994: 69).

It is unclear whether the seed-like designs were derived from the beech nuts or not. The iconography of Greek jewelry drew inspirations not only from the world of mythology and religion, but also from the world of flora and fauna. In addition to the seed-like and beech nut designs, fennel seeds and amphoras were also very popular in Greek iconographies. Many fruits, seeds, and trees (oak, olive and ivy) have been found on pendants as part of necklaces and earrings. Furthermore, some Greek gold jewelry was incorporated into the local traditions of the Scythian world. Beech-nuts were used as decorative elements for a diadem (Fig.14 a) found in a burial for a female at the Trekhbratnie kurgan in Eastern Crimea (Meyer 2013: 21), and the fennel seeds appeared in the ornamentation of a woman's headdress (Fig.14 b), alongside a range of relief plaques found in the Melitopoliskyi kurgan in Ukraine (Reeder 1999: 122).


***Figure 14. (a) Gold diadem from the Trekhbratnie kurgan in eastern Crimea, 4th century BCE, after Meyer 2013:21, fig.113; (b) Seed-like pendants on a woman's headdress, after Reeder 1999: 122***

It is not surprising that much of the gold jewelry found in the Royal Scythian tombs in the Black Sea region was strongly influenced by Greek art. During the first half of the 6th century BCE, when the Greek colonies were established at Pantikapaion and the Taman peninsula, lavish gold artefacts were produced by Greek goldsmiths to meet the increasing demands of local elites. In the Classical Age, itinerant goldsmiths often travelled between major craft centres at the invitation of the local aristocracy. The high-quality Scythian gold articles in the Black Sea region were produced in Olbia, which had been located in the central part of the Bosporan kingdom since the 5th century BCE (Bouzek 2012: 350-368).

Greek influence is also evident in other jewelry from the Greco-Roman world. There are occasional examples of the beech-nut pendants found in Gandharan art. The earrings (Figs.15 a and 15 b) excavated at Taxila (1st century CE) from the city of Sirkap are examples of the extraordinary multi-cultural mix of Parthian, Kushan, Scythian, Indian, and Hellenistic influences (Marshall 1951: 217; Krishnan & Kumar 2001: 68).

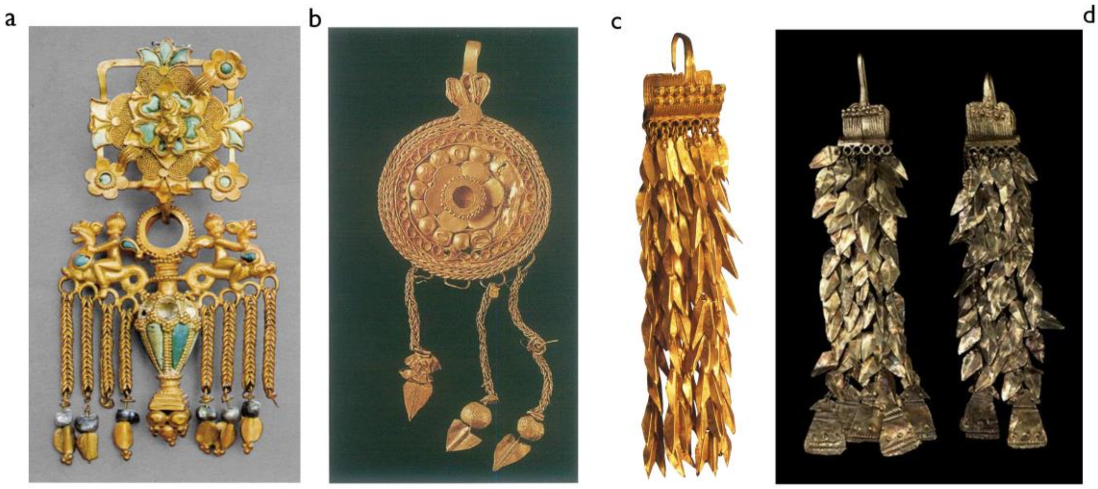


***Figure 15. (a) Earring with beech-nut pendant, Taxila, National Museum of Pakistan, Karachi, Photography by Christian Luczanits. Available online:***
***http:// www.pbs.org/newshour/art/asia-society-exhibit-explores-pakistans-buddhist-past;***
***(b) Earrings with beech-nut pendant, Sirkap, 1st century CE. After Krishnan & Kumar 2001:68, Fig.79;***
***(c) Earring from the Troy Treasure, Mesopotamia. 2200 BCE. After Schadt 1997:14, fig.13;***
***(d) Gold earrings from northeast Aegean, 2400 BCE. After Quick 2004:132, fig.120***

### *4.3 Homogeneity and variability*

The comparable examples beyond China prompt some key questions: what were the influences and from where did they originate? What were the prototypes that gave rise to the distinctive Dongtalede beech-nut pendants? To answer these questions, it is necessary to examine the homogeneity and variability in the typological, technical and chemical features of the Dongtalede gold ornaments and those from foreign lands.

#### 4.3.1 Typology

It is interesting to note that the beech-nut pendants found in Dongtalede and the Eurasian steppes were four-lobed, whereas the Greek ones were three-lobed. Some scholars have identified the three-lobed beech-nuts found in the Mediterranean world and the Black Sea area as spearheads because of the mention of these necklaces in some temple inventories. Williams and Ogden (1994: 42) argued that spearheads only had two lobes, whereas arrowheads had three lobes and pointed shoulders. Therefore, they concluded that the beech-nut design was a local innovation, probably made in Macedonian workshops, because the beech tree was very common in northern Greece.

Another typological variability lies in the shape of the beech nuts. The Greek pendants had pointed shoulder whereas the Chinese and the Eurasian steppe pendants had bump bellies. Strap necklaces with beech nuts were worn as late as the 2nd century BCE. In the Greco-Roman world, the beech-nut pendants became much shorter than those in the Classical period.

Although the Dongtalede pendants show evidence of a lobed beech-nut design that dates from an earlier period than the Mediterranean samples, the prototype of using olive leaves seems to have come from ancient Mesopotamia. The gold earring from the Troy treasure (2200 BCE) in present-day Hissarlik in Turkey, was decorated with elliptic leaves with flat surfaces (Bass 1970: 335-341; Schadt 1997: 14). The Troy earring consisted of ten rows of ribbed elliptic leaves made of thin gold sheet, and many of them were geminiflorous (Fig.15 c). Another similar example was a pair of gold earrings with single leaves (Fig.15 d) from the University of Pennsylvania Museum's holding, reportedly from the Early Bronze Age Aegean (2400 BCE) and purchased from Hesperia Art (Quick 2004: 132). The ribbed leaves from Troy shared certain typological similarities with the Dongtalede examples, although they were made in different ways. Each pair of leaves from Troy was carved and then pinched to create slightly raised ribs on the surface. The Troy pendants also had a two-dimensional structure without any soldering. This was different from the Dongtalede pendant, which was structured as a four-lobed beech nut joined with the welding technology.

### 4.3.2 The Joining Technology

The key technology for making beech-nut pendants is the joining. The best way to investigate the joining technology was to use microscopic examination combined with elemental analysis of the surface chemistry of the object, such as SEM-EDS, uPIXE and XRF. The techniques for joining precious metals that were known in antiquity were: (1) hard alloys brazing; (2) copper colloidal fusing; (3) sintering and (4) autogenous welding. Material science analyses are necessary to distinguish between each of these three techniques.

The hard-brazing often used Au-Ag binary or Au-Ag-Cu ternary gold alloys, which melts at a lower temperature than the parts that needed to be joined. To lower the melting temperature of a gold alloy, the concentrations of silver and/or copper were often increased. Such methods were practised in Mesopotamia from at least the 3rd millennium BCE (Higgins 1961: 34-35) and in ancient Egyptian workshops from at least the Middle Kingdom (2040-1782 BCE) (Lemasson et al. 2015: 279-286; Guerra & Pages-Camagna 2019: 143-152). The Au-Ag-Cu ternary alloy was also used to solder a crescent-shaped Greek pendant that dated from the 9th century BCE (Ogden 1998: 21-24).

Copper colloidal fusing (a mixture of copper salts with an organic flux) often produced thinner seams, and this technology spread in the Mediterranean world in the first millennium BCE (Echt and Thiele 1993: 435-451). When a joint is not visible, and the copper content in the joining area is higher than that of the metal substrates, it is reasonable to conclude that copper diffusion bonding was employed for soldering. The manufacture of the gold jewelry from the Troy treasure employed copper salt for soldering (Betancourt 2006: 89-95; Swann & Betancourt 1997: 320-323). Copper colloidal fusing was a very common way of manufacturing gold granulations in the ancient Etruscan civilization (Scrivano et al.2017: 185-193; Nestler & Fomigli 2010: 35-41).

Sintering does not produce any compositional changes in the welding region due to the use of gold powder that is a similar composition to the joined parts. The sintering technique has been identified in gold artefacts from Syria Sevilla (Prévalet 2014: 423--433; Ontalba et al. 2001: 664-669), as well as in the gold granulations from ancient Etruscan (Echt and Thiele 1993: 435-451). The SEM image of the ancient Etruscan gold jewelry shows that the joint between the grains revealed a narrow zone with a porous grained surface, indicating that the metal solidified from the liquid state, this could be achieved by heating the gold powders (Echt & Thiele 1995: 435-451). This granular structure (Fig.16 a) the in the welding area showed similarities with that of the Dongtalede pendant (Figs. 6 b and 6 c).

Autogenous fusing involves heating two homogeneous metals without adding any solder. Autogenous fusing technique has been observed in Sumerian gold objects from the Tomb of Queen Puabi at Ur (Maxwell-Hyslop 1977: 83-86). Some published work has revealed that gold cloisonné from central Anatolia also used autogenous fusing. In addition, a rippling effect could be observed on the surface of the gold, providing evidence of over-heating in many areas of the base plate and the components (Paterakis et al. 2015: 106-116).

The SEM-EDS results of the Dongtaldede pendants, however, attested to the presence of a hybrid of the sintering and the hot bonding techniques used for joining, this became more evident in the SEM images of sample M3:1-3 05: the granular structure is visible in the joining area b1, while the dendritic structure could be observed in the joining area b2, indicating that the melting point was reached (Fig.16 b). The heating temperature in b2 is much higher than that of b1. In antiquity, the goldsmith often used charcoal fire and blow pipes to reach the temperatures needed to melt gold (Nestler & Fomigli 2010: 43). It is very likely that the heat of b2 was intensified by a blow pipe acting from the left side.

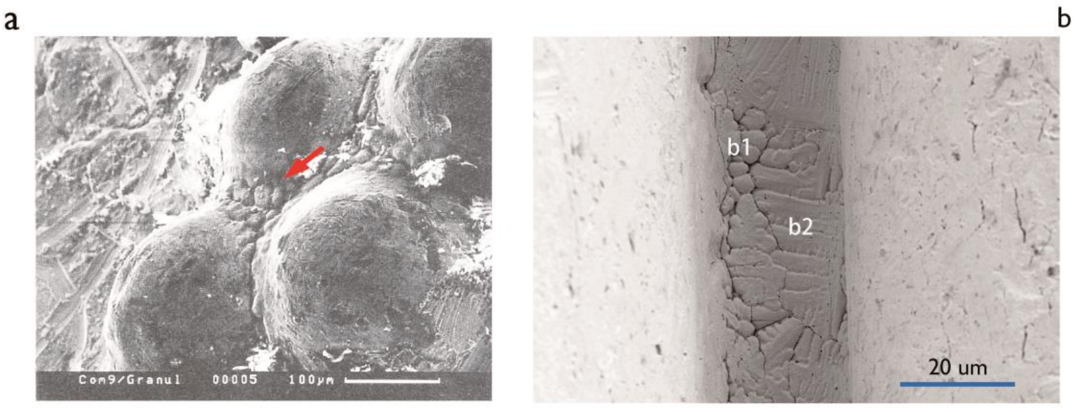


*Figure 16. (a) A granular microstructure in the joining area of the Etruscan granulation, after Echt & Thiele 1995: 438, fig.1; (b) SEM image showing the detail of joining area of the Dongtalede pendant M3:1-3 05*

### 4.3.3 Chemical Composition

The provenance of a metal—fingerprinting—can be inferred by two methods: either by measuring the concentration of characteristic trace elements present in the gold, or by determining the ratios of the different lead isotopes (Guerra et al. 1999: 1101-1110). Based upon the current non-destructive analyses of the Dongtalede gold, it is difficult to determine a precise provenance. The gold alloy showed a different composition from those found in the Southern Urals and the Mediterranean world, indicating that the gold for making the Dongtalede beech-nut pendants and their counterparts beyond China came from different sources.

A few scientific analyses of the Early Iron Age Greek gold have been undertaken to investigate the chemical composition of the gold alloy. The gold purities ranged from about 67 wt.% up to 99 wt.%. The Lefkandi gold was of remarkably high purity (Ogden 1998: 21-24). Gold jewelry from Tel el-Ajjul in Southern Palestine contained 84.31-92.50 wt.% Au, and 5.59-14.45 wt.% Ag, 0.54-6.01 wt.% Cu and 0.11-0.60 wt.% Fe (Politis et al. 2002: 441-450). Gold wreath found in Kabyle (4th century BCE) in the Black Sea region was highly refined (97.1- 99.9 wt.% Au) (Lesigyarski et al. 2015: 149-156). Gold objects from the Vulchitrun hoard (9th century BCE) in Bulgaria contained high percentages of gold, ranging from 91.14-92.18wt.% gold, with impurities of 8.49-9.37 wt.% silver (Todorov et al.2016: 1-15). The gold artefacts found in the Black Sea region and the Mediterranean world seemed to have a different composition from those in Central Asia and Northwest China.

The gold pendants from Dongtalede had a different composition pattern from the Central Eurasian samples. The elemental compositions of the gold appliqués in burial mound 4 of Filippovka I were 87-96 wt.% gold, 2-9 wt.% silver, and 1-2 wt.% copper. The gold foils from burial mound N1 of Filippovka II contained 94-87/86-79/75-62 wt.% gold, with 2-5 wt.% copper. The presence of Osmium, Ruthenium, and Iridium in gold objects and the surrounding alluvial deposits indicated the use of local alluvial gold (Zaikov and Zaikova 2015: 27-46; Zaykov 2018: 1-16). In the Taldy II cemetery, the gold artefacts contained up to 92.5 wt.% Au (Zaikov & Chugunov 2015: 145) while the gold content up to 90 wt.% at Arzhan II (Beisenov & Tairov 2015: 23-24). The Dongtalede pendants, on the other hand, were produced with the highest purity of gold, up to 98.54wt.% Au.

### *4.4 Local invention under the Hellenic influence*

The beech-nut pendants from Dongtalede have several typological, technical and compositional differences with other findings beyond China, though there are some similarities. One area of concentration of gold beech nuts can be identified in Northwest China and Central Asia between the 9th and the 6th century BCE. Another area of such artefact's concentration can be found in the Hellenic world in the region stretching from the Black Sea region to the Eastern Mediterranean between the 5th and 3rd century BCE. There is considerable archaeological evidence of women's artefacts and their diverse functions. While the iconography of olive leaves was ascribed to Greek art, the four-lobed beech nuts found in central Eurasia represent independent designs that employed complicated manufacturing techniques. It is much more likely these pendants were local inventions with the Hellenic influence.

In the Bronze Age China, gold was new to local elites in the Central Plains, where bronze and jades played more prominent roles in everyday life and rituals. However, it was highly valued by people on the Chinese borders, who had extensive contacts with the mobile pastoralists in the central Asian steppe (Bunker 1993: 27-50, Rawson 2015b: 1-60). The finding of gold artefacts at the Dongtalede cemetery on northwest Chinese frontiers, show that there was fine craftsmanship and sophisticated technology in the early stages of the development of gold manufacturing in ancient China (Xinjiang 2013: 4-18). In tomb 3 of Dongtalede, the beech-nut pendants were buried with small appliqués in the form of snow leopards, deer, and recumbent tigers, along with gold jewelry decorated with filigrees and granulations. There are close affinities with the zoomorphic imagery and decorative techniques found in other gold artefacts in Dongtalede and Central Asia (Yu & Ma 2013: 53-59). This has led some scholars to conclude that the gold artefacts found in Arzhan II were probably made by the craftsmen from Xinjiang and other regions of northern China (Kisel 2019: 93-123). However, the elemental analysis of some of the objects from Arzhan II in southern Siberia, and the Taldy II site in Kazakhstan showed a greater variety in metal composition (Tairov & Beisenov 2015: 21-25). This, along with the results of the gold analysis from northwest China, indicates that the gold came from different sources (Liu et al. 2021a: 1-29). The stylistic differences between the ornamental details suggest that they were not necessarily made in the same workshop.

Recent scholarship suggested that the ornamentations of gold jewelry found in central Eurasia and Southern Urals seem to have been inspired by the cultures of Achaemenid Iran and the Mediterranean world (Roes 1952: 17-30; Belaňová 2016: 111-126; Treister 2017: 261-266; Yablonsky et al. 2019: 29-161) from at least the 3rd century BCE. Early contacts between Northwest China, Central Eurasia and the

Mediterranean world are archaeologically documented in material record, although their relationship is indirect. The Greek influence on Achaemenid was evident in the Oxus Treasure found in present-day Tadjikistan, the most important hoard of material to have survived from the Achaemenid period. The gold signet-rings with engraved bezels had Greek designs, showing respectively Herakles, and they were considered Greek products (Curtis 2005: 115-123). The Achaemenid artistic tradition was a primary source of inspiration for the ornamentation of gold artefacts recovered from Arzhan II (Francfort 2016: 222-269; Chugunov 2016: 242-247) in the Sayan-Altai region and the Taldy II site in Kazakhstan while the nomadic Animal Style prevailed. At the Dongtalede cemetery, most stylistic features of gold artefacts can be compared with the Saka-Scythian style from the Sayan-Altai region and the Kazakh steppe while some elements, such as the beech-nut design may speak also for the artistic traditions from Mesopotamia or the Hellenic world.

There was more evidence for local productions adopting foreign techniques and styles across ancient Eurasia. From the 8th century BCE onward, a large number of gold artefacts rendered in the Scytho-Siberian animal style accumulated in the wealthy kurgans belonging to the powerful elites of the mobile pastoral groups in the central Asian steppes, as well as the elite burials on Chinese northwest frontiers (Fig.17a). Scientific studies affirm that gold sheet works were serially produced using the mould-pressing technique (Liu et al.2021b). These appeared as early as the third millennium BCE in the ancient Near East and prevailed in the Mediterranean world. Gold appliqués embossed with floral elements, animals, and human figures, were produced by hammering the thin sheet over a mould or a die. Examples of these (Fig.17 b) were recovered from the Shaft Grave III (1400-1200 BCE) of Mycenae (Laffineur 1991: 89-116). In a vast territory of mobile pastoralists in the Eurasian steppe, extending from the Sayan-Altai region, the Kazakh steppe (Beisenov 2020: 138-162) to southern Urals, millions of decorative appliqués with raised animal figures (Fig.17 c) were crafted from gold, showing off the status and wealth of their owners in the funerary context.

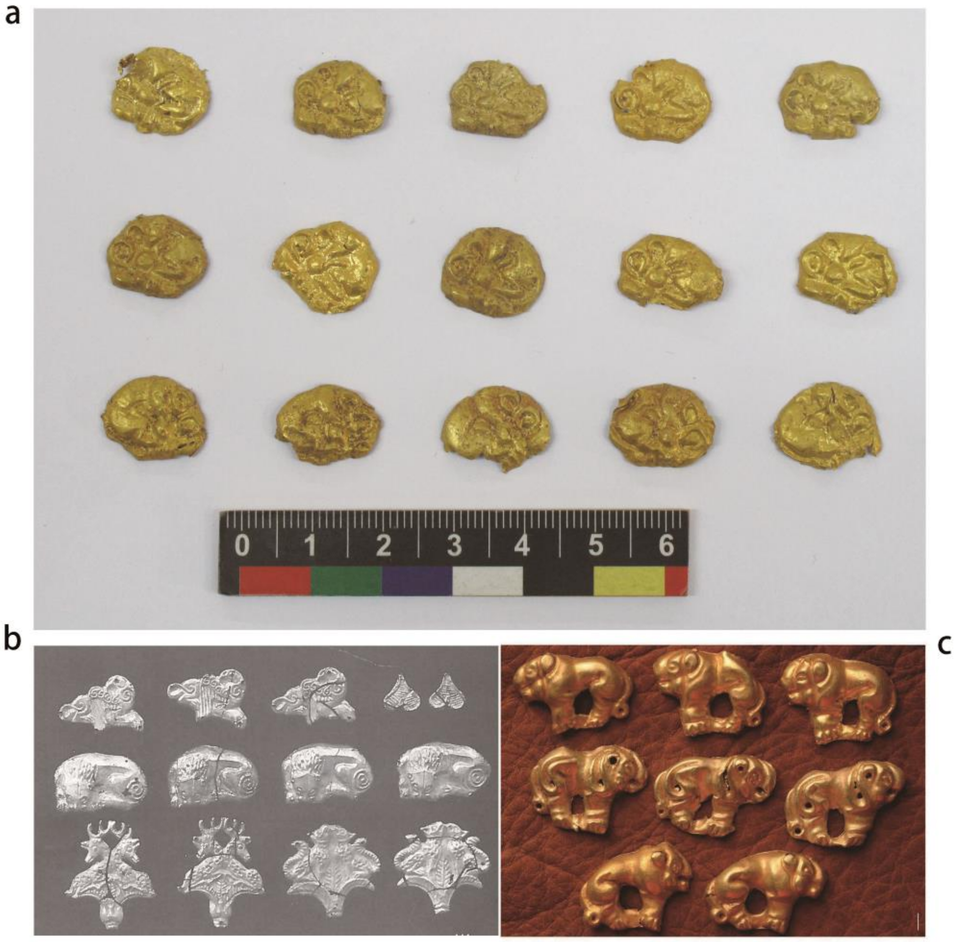


*Figure 17. (a) gold appliqués in the form of snow leopards found in Dongtalede, Northwest China; (b) gold appliqués found in Grave circle A, Mycenae, after Laffineur 1991: 92, fig.2; (c) gold appliqués in the form of standing tigers found in mound 5 of Taldy II, Kazakhstan, after Beisenov 2020: 151, fig.2*

## 5. CONCLUSION

The current investigation into the artistic style and manufacturing techniques of the beech-nut pendants from Dongtalede reveals information about an important early chapter in the history of metallurgical technology in Eurasian antiquity. The pendants studied here represent the earliest evidence of diffusion bonding used in gold production in Northwest China, dating from the 9th to the 7th century BCE. The current study of the elemental composition suggests that the gold pendants of Dongtalede were produced using natural gold that was very pure. The pendants differed from other contemporary examples in central China and the Eurasian steppes. In addition, the peculiar designs of the four-lobed beech-nut pendants in Xinjiang Altai and Central Asia were closely linked to the Mediterranean world, but there are several differences in the typological, technical, and chemical features. These point to local inventions with a Hellenic influence. Some questions remain due to the limited data. For example, it is not clear how to determine the centre of production from which the beech-nut pendants came, or how the welding technology was introduced to Northwest China. Further scientific analyses are required to investigate the microstructure and chemical composition of the comparable examples found in Central Asia and the Southern Urals, as well as the Mediterranean world, which would enrich the current data pool. This will require increased international cooperation for comparative research.

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